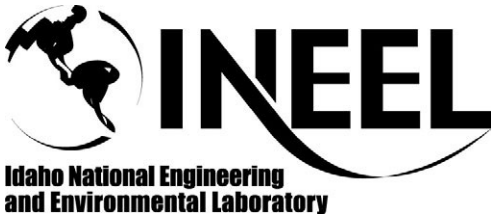

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DEFINING SCIENCE AND TECHNOLOGY (S&T) NEEDS FOR LONG-TERM STEWARDSHIP OF U.S. DEPARTMENT OF ENERGY SITES AND DEVELOPMENT OF AN S&T PLAN

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ABSTRACT

A definition of Long-Term Stewardship (LTS) is: "all activities required to protect human health and the environment from hazards remaining after cleanup is complete." "Cleanup" in this sense may mean completion of a prescribed remedy for contaminated soil or buried waste, or it could mean entombment of a nuclear facility or placing nuclear materials in safe, long-term storage. Among the activities included in this definition are long-term monitoring and surveillance, maintenance of engineered barriers, operation and maintenance of long-term remedies (such as groundwater pump and treat operations), institutional controls (e.g., deed restrictions, land use restrictions, permanent markers, etc.), and information management (including intergenerational transfer of data on residual hazards). The magnitude of the U.S. Department of Energy's (DOE) LTS commitments, in terms of scope, cost, and time, is beginning to be better understood.

The Idaho National Engineering and Environmental Laboratory (INEEL) has been chartered to assist DOE's Idaho Operations Office and the DOE Headquarters Office of Long-Term Stewardship in

1. planning and management of the National Long-Term Stewardship Program,
2. ensuring the effective transition of sites from cleanup to long-term stewardship,
3. ensuring safe and effective execution of long-term stewardship operations (in conjunction with the DOE Grand Junction Project Office), and
4. developing and implementing improvements to long-term stewardship operations and decision making through advances in science and technology (S&T).

An initial step in determining how advances in S&T can be applied in the LTS program is to identify LTS S&T needs. These are needs which, if advances in scientific understanding can be made or technologies developed to address the needs, may result in reduced risk, cost, or uncertainty of LTS activities, or improved reliability of LTS measures. After LTS S&T needs are identified, DOE will coordinate and manage a research and development program to address needs which aren't already being addressed through current projects.

In Fiscal Year (FY) 2000 (October 1999 through September 2000), we completed an *Initial Needs Assessment and Technology Baseline Inventory 2000* report (available on the Internet at http://emi-web.inel.gov/lts), and prepared a *Conceptual Framework for a Science and Technology Roadmap.* The needs were analyzed, sorted, and placed into categories where they seemed to logically group. The greatest number of needs identified were related to monitoring and surveillance. In FY 2001 (October 2000 through September 2001), we will initiate development of a LTS Roadmap. This Roadmap will lay out a plan for prioritizing and funding research and technology development that has the greatest potential for impacting cost and reliability of LTS actions.

IINTRODUCTION

A definition of Long-Term Stewardship (LTS) is: "all activities required to protect human health and the environment from hazards remaining after cleanup is complete." "Cleanup" in this sense may mean completion or construction of a prescribed remedy for contaminated soil or buried waste, or it could mean entombment of a nuclear facility or placing nuclear materials in safe, long-term storage. Among the activities included in this definition are long-term monitoring and surveillance, maintenance of engineered barriers, operation and maintenance of long-term remedies (such as groundwater pump and treat operations), institutional controls (e.g., deed restrictions, land use restrictions, permanent markers, etc.), and information management (including intergenerational transfer of data on residual hazards). The U.S. Department of Energy (DOE) is responsible for implementing LTS at numerous sites that have been

involved in nuclear research and development, or in the production of nuclear materials or weapons components. The magnitude of DOE's LTS commitments, in terms of scope, cost, and time, is beginning to be better understood. These LTS activities could include sampling and analysis of more than 11,000 monitoring wells, maintenance of barriers at hundreds of waste landfills, surveillance and maintenance of 15 nuclear reactors and numerous nuclear materials processing facilities, as well as the stewardship of nuclear materials for which no final disposition path has been determined.

The Idaho National Engineering and Environmental Laboratory (INEEL) is the DOE Lead Laboratory for Science and Technology (S&T) for LTS. In addition to providing program support to the DOE Idaho Operations Office and DOE Headquarters Office of Long-term Stewardship, part of the INEEL's charter is to identify S&T needs for LTS (i.e., those that have the potential to significantly reduce risk or cost), to identify current capabilities to address those needs, and to coordinate and manage a research and development (R&D) program to address needs which aren't being addressed by existing capabilities. This identification of needs and planning the R&D program is sometimes called a "roadmap." The execution of these needed S&T activities will involve participation of other DOE laboratories, academia, and industry.

METHODOLOGY FOR ASSESSING NEEDS

To guide the initial assessment of needs, the assessment team developed a systematic approach to identifying potential long-term stewardship science and technology needs. The process they developed included the following tasks:

1. Determining what sources of potential needs were available

2. Developing a methodology, screening criteria, and an electronic database as tools to help identify or evaluate those sources

3. Collecting the potential needs from those sources (e.g., reports, interviews)

4. Screening all potential needs to identify those that met the LTS definition

5. Sorting and categorizing the LTS needs

6. Evaluating the LTS needs and available technologies to initially determine where gaps exist and where research or technology development might be required.

Many legitimate scientific and technological needs have long-term implications that, if addressed, would have long-lasting impacts. However, for the purposes of this assessment, if a need is primarily critical to the cleanup mission (for example, related to characterization or treatment), then it was not considered a long-term stewardship need. Also excluded from this initial needs assessment were long-term stewardship needs associated with waste repositories, such as the Waste Isolation Pilot Plant in New Mexico where waste contaminated with transuranic radionuclides is being disposed in deep salt formations, and the proposed Yucca Mountain repository in Nevada for spent nuclear fuel. These facilities will have needs that are specific to their operations and locations.

After the process was established, the focus turned to identifying appropriate sources of information from which needs could be extracted. Since time and funding limited the scope of this initial effort, the target sources became (a) existing DOE Office of Environmental Management (EM) needs documentation, (b) reports, (c) limited interviews with site operations personnel, and (d) internal memoranda. Each of those sources of information regarding potential long-term stewardship needs is discussed below.

Existing DOE Documentation

Numerous processes have been employed within DOE to identify, prioritize, and track needs for research or technology to solve critical EM problems. These processes have used DOE site operations, environmental restoration and waste management, and research personnel, along with regulators and others with an interest in the sites, to define where needs exist for technology development. The needs identified by these groups are found in numerous DOE-EM documents and databases. A review of these sources led to the conclusion that the best single source for evaluating existing needs specific to DOE sites was the Needs Management System, or NMS, (now incorporated into the Technology Management System), a database that describes the needs identified by DOE Field Offices and sites.

Published Reports

In addition to the NMS, several reports were found to be sources of potential needs. One such report is the draft *National Defense Authorization Act (NDAA) Report to Congress on Long-Term Stewardship at DOE Sites* (final report issued January 2001) which describes planned stewardship activities at DOE facilities. The report is organized with one chapter per state, and a few of these chapters summarize needs for technology that could improve reliability or reduce the costs of planned stewardship.

The following reports also identified needs that applied to long-term stewardship:

1. *Managing Data for Long-Term Stewardship*, Working Draft Report, ICF Kaiser Consulting Group, March 1998

2. *Research Needs in Subsurface Science*, National Research Council of the National Academies of Science, March 2000

3. *DOE Complex-Wide Vadose Zone Science and Technology Roadmap: Characterization, Modeling, and Simulation of Subsurface Contaminant Fate and Transport, Vadose Zone Science Integration and Technical Basis (Draft)*, INEEL/EXT-2000-00112, May 2000

4. *Environmental Management Science Program, Sensors Initiative for Identification of Long-Term Stewardship Research Needs (Working Draft)*, Workshop Held in Idaho Falls, ID, June 19 & 20, 2000

Interviews with Personnel Responsible for Site Operations

The third category of source information for potential needs was interview information from DOE site personnel. Selected interviews were conducted with personnel from INEEL (a large continuing mission site where nuclear research and waste disposal operations have occurred), the Grand Junction Project Office (which has responsibility for long term surveillance and maintenance at a number of sites around the country, such as those where uranium mining and milling took place), and Weldon Spring (a former uranium processing site where most of the remediation has been completed) to obtain input from operational organizations that will be responsible for carrying out stewardship activities. Although no onsite interview was conducted at Fernald (a facility in Ohio where uranium was processed), information regarding current needs and future stewardship-related needs was obtained from that site by telephone and an informal memorandum (see below). Science and technology needs resulting from these interviews were screened, using the same criteria as the NMS needs and the needs identified from reports, to determine which ones had long-term stewardship implications.

Memoranda

The final category of needs information consisted of two internal memoranda. The first was an internal INEEL memorandum briefly summarizing general conversations among DOE and INEEL personnel regarding potential needs. The second was an informal memorandum, provided to the INEEL, that

documented a preliminary set of needs developed by Fernald Environmental Management Project personnel to be used as a starting point for further discussions among project personnel and stakeholders.

Screening/Sorting of LTS Needs

Over 900 potential needs (about 800 from NMS) were identified from the sources described above. In order to screen and categorize these needs, a set of questions about a potential need was developed to determine its relationship to long-term stewardship (i.e., if it is a need related to an activity required to protect human health and the environment from hazards remaining after cleanup is complete). These questions and comments were then incorporated into a database so that a uniform, documented process of evaluating needs and tracking results was used. The actual screening was conducted by an interdisciplinary technical working group to foster discussion and reach consensus as the evaluation questions were applied to each potential need. The results (positively answered questions) were captured in the database to allow further sorting, evaluation, and display.

The first screening question is really a "go/no-go" criterion to determine if the need was related to post cleanup (an LTS activity). For the purposes of this initial need assessment screening exercise, the decision was made to identify only S&T needs that are related to post-cleanup activities. So, the first question is: "Is it related to or does it ensure or demonstrate protection of human health or the environment after cleanup, disposal, or stabilization is completed?"

As stated before, there are S&T needs that have long-term implications, or needs that if addressed, would have long-lasting impacts. Needs related to making waste forms more robust are examples of needs with long lasting impacts yet were not considered to be LTS Needs. Again, if the need is primarily critical to the cleanup mission (e.g., related to characterization or treatment), then it was not considered an LTS S&T need in this assessment. A comment "box" was added to the database to identify those needs determined not to meet the first criterion but that nevertheless had LTS implications. Some science needs are related to better understanding of fate and transport of contaminants and have long-term implications, even though the need is primarily focused on improving knowledge necessary to make a better remedy selection. There is a broad suite of subsurface science needs that fit this description. These needs were categorized as LTS in the initial needs assessment because they represent such an extensive set of comprehensive needs that are applicable to many DOE cleanup decisions and follow-on activities.

If a need passed the first screening question, then a number of other questions (which are not prioritized or weighted for importance at this stage) were asked to help further understand and categorize the needs. For example:

- Is it or does it pertain to site maintenance?
- Does it relate to better understanding of the final engineered system performance?
- Does it contribute to a greater understanding of fate and transport of contaminants?
- Does it improve data management?
- Does it enhance the overall confidence in projected risk estimates?

A number of needs were identified that truly are LTS Needs, but were determined not to be primarily science and technology related needs. Examples include: how to ensure funding of stewardship for very long periods, issues of intergenerational equity, possible needs for regulatory changes, etc. A question and category of "non-S&T needs" was included to be able to track these needs.

After this set of questions was addressed, each need (except non-S&T needs) was further categorized to determine if it was related to:

- Waste Form/Physical Barriers
- Data Collection/Transmission
- Information Management
- Environmental Setting and System Performance, or
- Crosscutting Issues.

Within each of these five categories, additional attributes were identified to assist in analyzing needs. For example, for needs dealing with Information Management, each need was further evaluated for the attributes of Data Analysis, Data Interpretation, Reporting, Accessibility, Retention, Records Management, and Cost of Records Management. Each attribute that applied received a "check" in the database.

Needs that passed the go/no-go criterion (i.e., those that were determined to be LTS Needs) were then sorted by querying the database for certain criteria or combinations of criteria. After evaluating the results through numerous types of sorts, it was determined that the 152 needs identified as LTS Needs grouped into the following "logical" categories:

- Surveillance and Monitoring
- Subsurface Science
- Caps and Covers
- Physical Barriers
- Information Management
- Ecosystem Monitoring
- Toxicity
- Non-Science & Technology

NEEDS ASSESSMENT FINDINGS

Of the 917 potential needs (over 800 from the NMS) that were evaluated, 152 were determined to be LTS Needs. Because so many of the potential needs that were evaluated were taken from the existing NMS database, most of those that were determined to be LTS Needs also came from NMS. Figure 1 shows the number of LTS Needs from each source category.

Figure 1. LTS Needs by Source

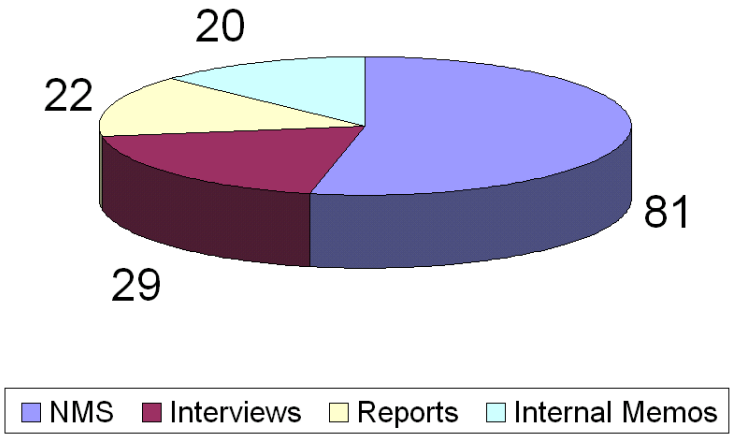
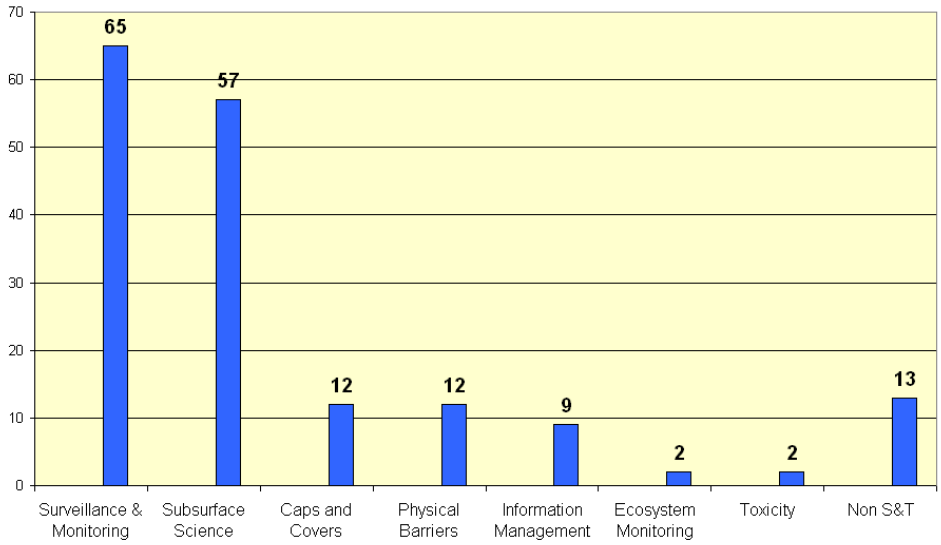


Figure 2 illustrates the distribution of the 152 LTS Needs among the logical categories into which they were grouped. Note that the numbers in this figure total to more than 152 because some of the 152 LTS Needs were placed in more than one category.

Figure 2. LTS Needs by Category



This set of 152 needs serves as an initial baseline of S&T needs that are related to LTS. Because many of them were derived from an existing set of needs (the NMS) that were not initially meant to necessarily relate to LTS, the numbers of needs in each category should be viewed with some caution. For example, because the number of needs in the Surveillance and Monitoring category (65) is about 7 times the number in the Information Management category (9), one should not infer that the Surveillance and Monitoring category is roughly 7 times more important than the Information Management category. The relative number of needs in each category is partly an artifact of the sources of needs that were evaluated, and no prioritization or weighting of categories was applied during this assessment. While the numbers of needs in each category may not have a great deal of significance, the categories do seem to be legitimate areas where investments in S&T research and development can have an impact on future LTS costs and effectiveness.

PLANNED ACTIVITIES FOR ROADMAP DEVELOPMENT

What is a Roadmap?

A roadmap is a portrayal of the R&D activities and schedule necessary to manage technical risks and opportunities associated with a complex cleanup or stewardship problem. Roadmapping helps identify technical capabilities required for a project or program and provides the basis for project plans that ensure the required knowledge and technologies will be available when needed. Roadmapping develops a consensus among science and technology users, providers and management about what R&D is needed. It is a plan for conducting needed R&D.

Collect Technical Baseline Data

In order to prepare a roadmap that addresses identified S&T needs, a minimum set of data from each site must be collected and evaluated. Data about DOE sites that are in some phase of stewardship or that

are planning to transition to stewardship are available from a variety of sources. One such source is the *National Defense Authorization Act (NDAA) Report to Congress on Long-Term Stewardship at DOE Sites* (DOE/EM-0563, January 2001). This report contains data for 129 sites that will or may require some level of stewardship by DOE. The data that were used as the basis for the Report to Congress will be used as a starting point for the Technical Baseline. Additional DOE and DOE-contractor databases, reports, regulatory agreements, and other sources will be used to ensure that a consistent set of data for each site is evaluated. The information to be collected will include such things as description of remedial action performed, geographic location and size, type of waste or residual contamination, quantities of radionuclides or chemicals, current or planned monitoring activities, schedules, and actual or projected end states (the state or condition of the site at the completion of cleanup activities and the beginning of the stewardship phase). A Technical Baseline Report summarizing the data collected is scheduled for completion by the end of September 2001.

Initiate Development of an LTS Roadmap

The following paragraphs describe activities and events that are planned at the time of preparation of this manuscript (June 2001). Current plans are to have an initial LTS S&T Roadmap in place by May 2002. This Roadmap will identify areas where S&T can be applied to decrease costs and improve the reliability and effectiveness of LTS activities, and will set out a path for funding promising R&D projects to reach that objective. Initiation of development of this Roadmap will take place in the second half of FY 2001 (April to September 30, 2001).

The development of the Roadmap will be coordinated with the DOE LTS Executive Steering Committee (ESC) and the DOE LTS Working Group. The Executive Steering Committee, which first met in May 2001, is comprised of senior-level managers from DOE-Headquarters program offices and from DOE Field Offices with responsibility for managing sites. This committee is charged with determining strategic objectives for the LTS program, and with identifying the need for and establishing policies that guide the program. The Working Group provides support to the ESC by preparing background information and issue papers that will be used by the ESC as they discuss LTS issues that are broadly applicable to the DOE complex.

Additionally, the LTS S&T Roadmap activities will be coordinated with other roadmapping efforts currently underway in DOE. In particular, the LTS Roadmap will benefit by communicating with participants responsible for preparing the DOE Complex-Wide Vadose Zone S&T Roadmap (available at http://www.inel.gov/vadosezone/roadmap/), and, to the extent possible, will follow the steps that have proven to be successful for that Roadmap.

After the Roadmap's general scope is determined, an LTS Roadmap Steering Committee will be formed to help guide the Roadmap development. Candidate groups for this Steering Committee include DOE (both Headquarters and Field), DOE contractors (operational sites and National Labs), other Federal or State agencies, University personnel, industry participants, and stakeholders. A mission statement and charter for the Steering Committee will be prepared, and the Committee will then provide further guidance on preparation of the Roadmap, including goals and schedules.

Working Groups will be formed to address specific topical areas of the Roadmap. Each Working Group will include subject matter experts in that particular area and the personnel who participate in these groups will again come from DOE, DOE contractor organizations, other agencies, Universities, industry, and stakeholder groups. The Steering Committee will make the final decisions on the topics for the Working Groups, but the five Working Groups currently envisioned include:

- Environmental monitoring Working Group,
- Physical Processes Working Group,
- Treatment/Continuous Improvement Working Group,
- Institutional Controls Working Group, and
- Intergenerational Impacts Working Group.

Assembling the Roadmap Steering Committee, obtaining agreement on the overall scope and schedule for the Roadmap, determining the appropriate Working Groups, and identifying Working Group participants will be completed at the end of FY01 (September 2001). This will set the stage for continuing Roadmap activities into FY02, starting in October 2001.

Roadmapping activities in FY02 will include assessing the technical needs related to LTS and comparing those needs to existing technologies and R&D programs. Technologies and R&D programs of all parts of the DOE as well as external programs will be considered. The result of this comparison of needs and available capabilities will be the basis for the LTS S&T Roadmap. The initial Roadmap is scheduled for completion in May 2002 and will define the scope of S&T investments needed to ensure an effective and efficient LTS program. The needs, available technologies, and R&D efforts will then be routinely reviewed in subsequent years.

THE DOE LTS S&T ROADMAP HAS WORLDWIDE APPLICABILITY

U.S. DOE sites that have conducted nuclear power research, nuclear materials production and processing, nuclear weapons (or components) research and production, and waste disposal are similar to facilities in many other countries. The U.S facilities are located in a variety of geological and environmental settings, ranging from humid sites where the depth to groundwater may be on the order of one meter, to arid sites where the vadose zone may be greater than a 100 meters. Some sites are located in remote areas, while others are now in relatively densely populated areas.

Many similar facilities around the world have reached their designed lifetimes, their missions have been eliminated, or for one reason or another, are no longer needed. Sites in many countries have buried waste or residual contamination problems that are similar to those of U.S. facilities. In addition, those sites have geological, environmental, and demographic situations that may be similar to those in the U.S.

Other countries may not use the phrase “long-term stewardship” in the same way as the DOE currently does, but many countries are facing problems that are nearly identical to those being addressed by DOE’s cleanup and LTS programs. It is believed that the DOE LTS S&T Roadmap and the subsequent R&D and technology development will be broadly applicable to international situations.